Habitat Connections

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BASIS FOR CONCERN ABOUT THE HYPOXIC ZONE IN COASTAL LOUISIANA

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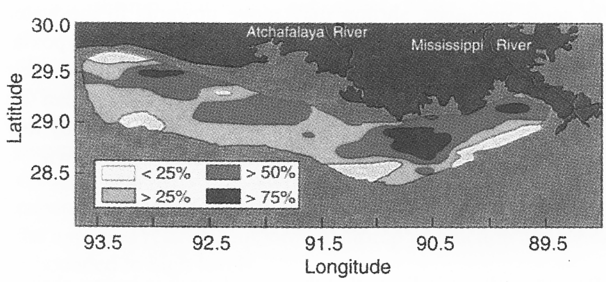
Introduction

There is no doubt that Louisiana is rich in fishery resources, or that its wealth of seafood production is attributable to freshwater, nutrients and sediments emanating from the Mississippi River. This outflow of the Mississippi River has indeed created a fertile fishery crescent unmatched anywhere along the coasts of the United States (Grimes, 2001). NMFS reporting of fisheries landings solidly supports Louiana s preeminent position as a leading state in seafood production. It also is well known throughout the world that the most productive fisheries are often associated with plankton blooms fueled by river borne nutrients. Even so, in nutrient enrichment there can be too much of a good thing, which can lead to nutrient over-enrichment and reduced levels of oxygen. It is the immensely valuable fisheries in Louisiana and the risk of over-enrichment and disturbance caused by the expanding hypoxic or dead zone that is the reason for heightened concern.



Map of Louisiana coast showing areas where mid-summer hypoxia occurs most frequently. The map is approximately 275 miles wide (the distance from Des Moines to Chicago) (unpublished data from Rabalais, Turner, and Wiseman). The colored areas, i.e., <25%, >25%, >50%, >75%, indicate the frequency of occurence of hypoxia during mid-summer of 1985-1997. The sampling grid has been held as constant as possible since 1985.

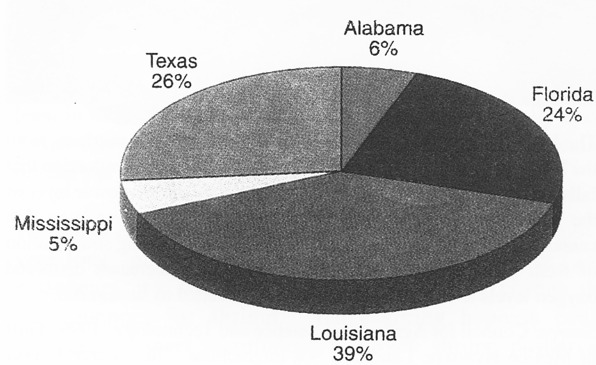
Source: Council for Agricultural Science and Technology. 1999. Gulf of Mexico Hypoxia: Land and Sea Interactions. Task Force Report No. 134. CAST, Ames, Iowa.

The concern about the phenomena raised by many scientists has extended to those who fish the waters and to the many state and federal governmental agencies involved in management of the Mississippi River watershed. The risk of this ecosystem degradation on the Louisiana shelf led to establishment of the Mississippi River/Gulf of Mexico Watershed Nutrients Task Force in 1997. The National Science and Technology Council s Committee on Environment and Natural Resources had already taken steps in 1997 to assess the state of scientific knowledge of Gulf of Mexico hypoxia and, by March 1998, through the Task Force, developed an assessment plan.

The assessment plan examined:

- the distribution, dynamics and causes of the hypoxia;
- the sources and loads of nutrients transported by the Mississippi River to the Gulf of Mexico;
- the ecological and economic consequences of the hypoxia;
- the effects of reducing nutrient loads;
- the methods for reducing nutrient loads; and
- the social and economic benefits of implementing mitigative steps.

A science assessment was completed in May 2000, when the summary report titled *An Integrated Assessment of Hypoxia in the Gulf of Mexico* was published. A management plan, entitled *Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico,* was published in January 2001. The plan is being implemented to reduce the frequency, duration, and size of the hypoxic zone in the northern Gulf of Mexico. It was developed by the Task Force, utilizing the scientific information provided in the science assessment and the many public comments on the *Integrated Assessment.* The Task Force also considered several other significant reports, including *Gulf of Mexico Hypoxia: Land*



Commercial fishery value by state for the Gulf of Mexico during 1996. Total value of yield for all states was approximately $690 million (NOAA data).

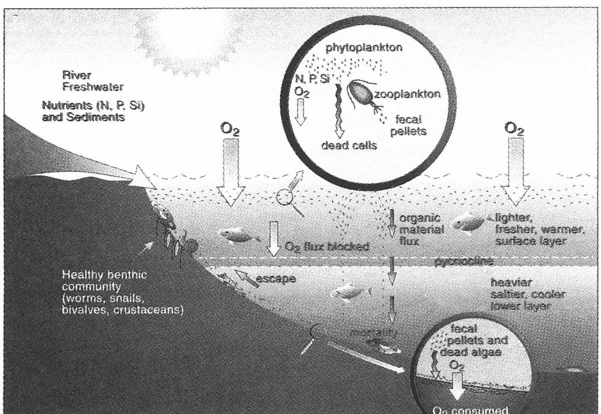
Source: Council for Agricultural Science and Technology. 1999. Gulf of Mexico Hypoxia: Land and Sea Interactions. Task Force Report No. 134. CAST, Ames, Iowa.

and Sea Interactions (Downing et al., 1999), *The Role of the Mississippi River in Gulf of Mexico Hypoxia* (Carey et al., 1999) and *Clean Coastal Waters: Understanding and Reducing the Effects of Nutrient Pollution* (National Research Council, 2000). All of the coordinated planning and resulting actions have been undertaken for scientifically-supported reasons; most actions attempt to preserve the Louisiana shelf ecosystem and its exceptionally valuable fisheries.

Also, there is evidence from past and ongoing investigations that the dead zone, or, more accurately, the hypoxic zone, impacts commercially important seafood species. The following information demonstrates how commercial shrimp are affected by the hypoxia.

Impacts of Hypoxia on Commercially Important Shrimp

Past investigations show that both shrimp and fish species avoid hypoxic waters. Fishery-independent surveys using bottom trawls reveal reduction or complete absence of shrimp and fishes in waters with very low oxygen content. The abundance and biomass of finfishes and shrimps are significantly lessened where oxygen concentrations in bottom water fall below 2 mg/l (Leming and Stuntz, 1984). Several explanations are possible — the shrimp or fish may die; they may move away either horizontally along the bottom or vertically upward into the water column; or they simply may not be attracted to the area in the first place.



The hypoxic zone in the Gulf of Mexico arises because nutrients from the Mississippi River Basin fuel excess marine primary production that falls to the bottom and decomposes in the denser, saltier lower layer of the sea. Decomposition consumes oxygen in the lower layer that cannot be renewed from surface waters because of strong stratification of fresh and salt water. Oxygen consumption decreases dissolved oxygen levels to below the concentrations needed to sustain life.

Source: Council for Agricultural Science and Technology. 1999. Gulf of Mexico Hypoxia: Land and Sea Interactions. Task Force Report No. 134. CAST, Ames, Iowa.

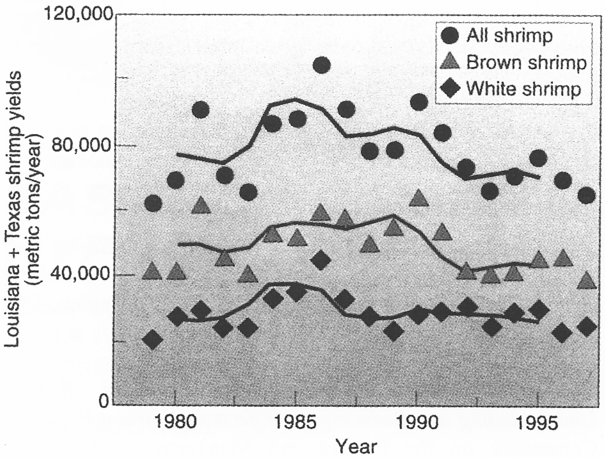
Laboratory experiments with shrimp confirm that commercial species have the ability to detect and avoid water with low oxygen concentration (Renaud, 1986). Under experimental laboratory conditions, white shrimp avoid water with dissolved oxygen lower than 1.5 mg/l and brown shrimp are even more sensitive, avoiding water having less than 2.0 mg/l dissolved oxygen. It is likely that the ability to detect and avoid water with low oxygen leads to an apparent blocking effect by hypoxic waters on shrimp emigrating from inshore nurseries to offshore feeding and spawning grounds. In a mark-recapture study of shrimp migration, juvenile brown shrimp leaving marsh nurseries were shown to be blocked from normal movement offshore by an environmental barrier (Gazey et al., 1982). Moreover, offshore migration by brown shrimp was reported to be greater and catches larger during periods when hypoxia was not evident as compared to periods when hypoxia was observed (Renaud, 1986a). Avoidance, or crowding, of shrimp and fish away from hypoxic waters has been repeatedly observed in phenomena called "jubilees" (Loesch, 1960).

Recent analyses further suggest a localized negative relationship between shrimp catch and hypoxia (Zimmerman et al., 1997). Where hypoxia is widespread and persistent on the Louisiana shelf, the shrimp catch is always low. If blocking by hypoxia of shrimp migration offshore does occur, shrimp distributions and densities are modified. Indeed, in Louisiana, the near-shore concentration of shrimp is known to be orders of magnitude higher than in the hypoxic zone. Also, shrimp movement appears to be diverted westward, parallel to the coast in the direction of the prevailing coastal current, during periods of hypoxia. Such large- scale disruptions to shrimp distributions can be expected since as much as 50% of the Louisiana shelf is affected by hypoxia during the summer months. This is the period when juvenile brown shrimp migrate offshore and when adult white shrimp spawn on the inner shelf.

In some instances, shrimp may move upwards in the water column as a short-term means of escaping bottom hypoxia. Such vertical movement would substantially increase their exposure to predation and increase mortality. It can be assumed that some shrimp mortality is directly caused by low oxygen levels, but the extent of that mortality is unknown.

Reduction in shrimp catch

Recent analyses indicate that the annual catch in brown shrimp fisheries of Texas and Louisiana decreases significantly when the hypoxic zone expands (Zimmerman and Nance, 2001). During the years between 1985 and 1998, the area of hypoxia on the Louisiana shelf nearly doubled to 18,000 square kilometers (Rabalais et al., 1998; Downing et al., 1999). Within this interval, brown shrimp catch declined from moderately high levels in the late 1980 s (approximately 42 thousand metric tons per year) to low levels in the 1990 s (approximately 32.5 thousand metric tons per year). This reduction amounts to 22.6% of the previous catch, representing approximately 9.5 thousand metric tons less brown shrimp per year for Texas and Louisiana fisheries. A decline in catch per unit effort (CPUE) in the brown shrimp fishery also corresponds with expansion in hypoxia. Average catch rates of brown shrimp changed from 11.2 kg/h to 9.1 kg/h from the 1980 s to the 1990 s (Downing et al., 1999). Notably, white shrimp, which is a near-shore species and



Trends in shrimp yields recorded by the National Marine Fisheries Service for Louisiana and Texas. All shrimp includes species with recorded annual yields greater than 1,000 metric tons. Lines indicate 3-year moving averages. Data supplied by personal communication through the National Marine Fisheries Service Statistics and Economics Division.
(hhtp://www.st.nmfs.gov/st1/commercial/landings/index.html)

Source: Council for Agricultural Science and Technology. 1999. Gulf of Mexico Hypoxia: Land and Sea Interactions. Task Force Report No. 134. CAST, Ames, Iowa.

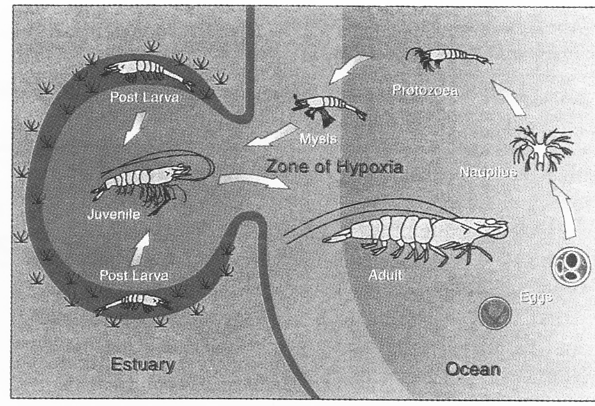


Diagram of the life cycle of Gulf of Mexico shrimp. Eggs released in the ocean develop into larvae that migrate into inshore estuaries to grow into juveniles. Juveniles migrate out to sea where they grow into adults that are commercially harvestable size. Migration to the sea can be blocked by the hypoxic zone (right), which is avoided by migrating juveniles.

Source: Council for Agricultural Science and Technology. 1999. Gulf of Mexico Hypoxia: Land and Sea Interactions. Task Force Report No. 134. CAST, Ames, Iowa.

outside the influence of hypoxia, did not demonstrate the same declining trends in catch and CPUE as brown shrimp. Over the same period between 1985 and 1998, white shrimp catch remained within the expected range of annual variability.

The changes in catch indicate an environmental impact to brown shrimp that does not affect white shrimp. The cumulative evidence suggests that the impact is caused by, or at least associated with, expansion of hypoxia. The effect of hypoxia on brown shrimp may co-vary with other factors such as the effect of freshwater on the relative size of the inshore nursery area available to juvenile shrimp. For example, the drought year of 2000 caused the inshore nursery area to expand and the offshore hypoxia area to diminish. Following the expected relationship, brown shrimp production and catch rebounded to high levels.

Regardless of the co-varying relationships, the lowering of annual catches in the 1990 has been closely correlated to expanded hypoxia. True, the details of how hypoxia affects brown shrimp production in offshore waters are still unknown. Also, it is not known whether cumulative environmental factors are involved and what their weighting might be, or whether negative effects on shrimp catch during one year translate into subsequent years.

Influence on distribution of catch and effort

Spatial effect: During the late spring and throughout the summer months, when hypoxia occurs, the Louisiana near-shore and inshore shrimp fisheries are at their peak. These fisheries target juvenile shrimp as they migrate from estuarine nurseries and when individuals are still relatively small in size and not yet adults. If expansive hypoxia blocks migration into deeper offshore waters, the effect increases the concentration of shrimp on the near-shore shelf. Since shrimp fishermen target concentrations of shrimp, most of the trawling effort in Louisiana remains near-shore. Thus, the relatively dense concentration of shrimp in the area between the hypoxic zone and the shoreline favors and helps to maintain the near- shore fishery in Louisiana.

Such is not the case in Texas where juvenile brown shrimp migrate offshore without impediment by hypoxia. In Texas, an offshore fishery is favored since the population can easily disperse across the shelf where individuals grow to adult size in deeper waters. Juveniles are fished by a restricted number of vessels within Texas bays; subadult shrimp that migrate out of the estuaries are protected by a temporary offshore fishery closure. Juveniles that escape the Louisiana fishery also can move down-current into Texas waters. This movement may cause a dependency of the Texas catch on Louisiana production. The apparent dependency has strengthened over the years and, since 1980, the success of brown shrimp in Texas has become significantly related to Louisiana catch. At least in theory, Louisiana may be dependent reciprocally upon Texas for offshore spawning by brown shrimp to replenish postlarvae in its estuaries each year.

Temporal effect: Under most circumstances, hypoxia is not a year-long phenomena. Although hypoxia arrives and disappears, it s size, timing and duration may change the consequences for shrimp. Early spring hypoxia could negatively impact recruitment of brown shrimp postlarvae into nurseries. Large- scale, near-shore hypoxia during the spring could impinge on white shrimp spawning areas. Large-scale summer hypoxia can impede brown shrimp juveniles from moving offshore. Extension of summer hypoxia shoreward may adversely crowd shrimp and intensify fishery trawling effort in localized areas.

Influence on Spawning and Feeding Habitat

Shrimp spawning grounds in Louisiana are likely impacted by hypoxia. The spawning area for white shrimp can be reduced during the spring and summer when hypoxia extends close to shore and the timing and location of both events coincide. Spawning grounds of brown shrimp may be eliminated entirely in offshore Louisiana during the months in which hypoxia occurs. Re-routing of juveniles into Texas waters during summer months also can lessen the numbers of adult brown shrimp offshore of Louisiana after hypoxia disappears in fall and winter months, which are the peak spawning periods for brown shrimp.

Summer hypoxia in a band along the coast of Louisiana blocks access of juvenile shrimp migrating to offshore feeding grounds. In areas where severe hypoxia has killed infaunal annelid worms, which are important prey for brown shrimp, the forage value of habitat is diminished. Losses in production due to lost feeding and impairment of growth may be significant, especially for brown shrimp. The losses in productivity are worse when the hypoxic zone expands in space and time.

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